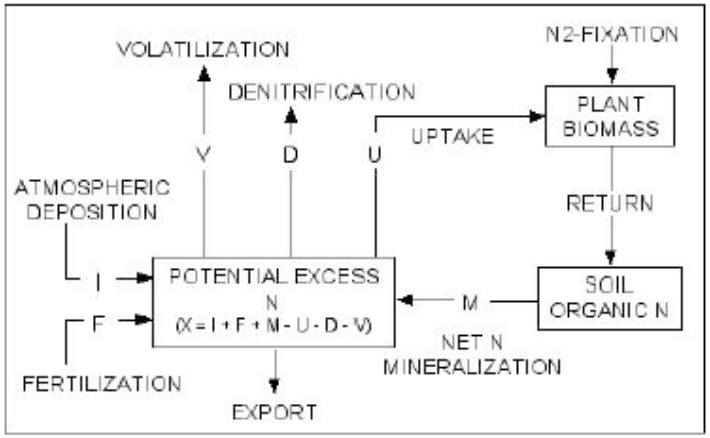
OAK RIDGE NATIONAL LABORATORY
U. S. DEPARTMENT OF ENERGY

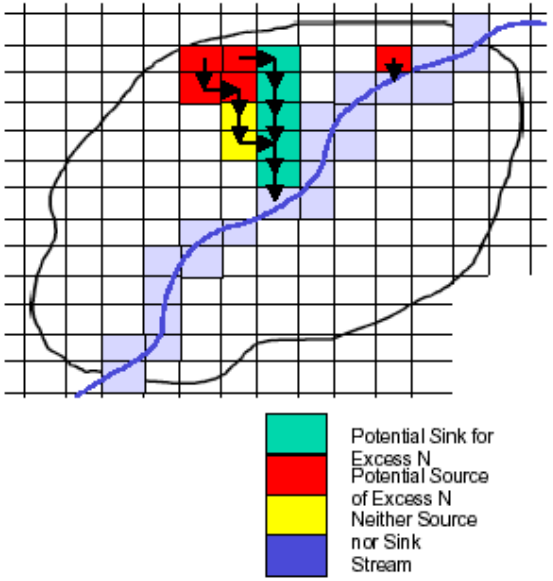
DoD EPA DOE SERDP
Strategic Environmental Research and Development Program
Improving Mission Readiness Through Environmental Research

Spatial Modeling of the Leakiness of Nitrogen from Ft. Benning Army Base and The Surrounding Watersheds

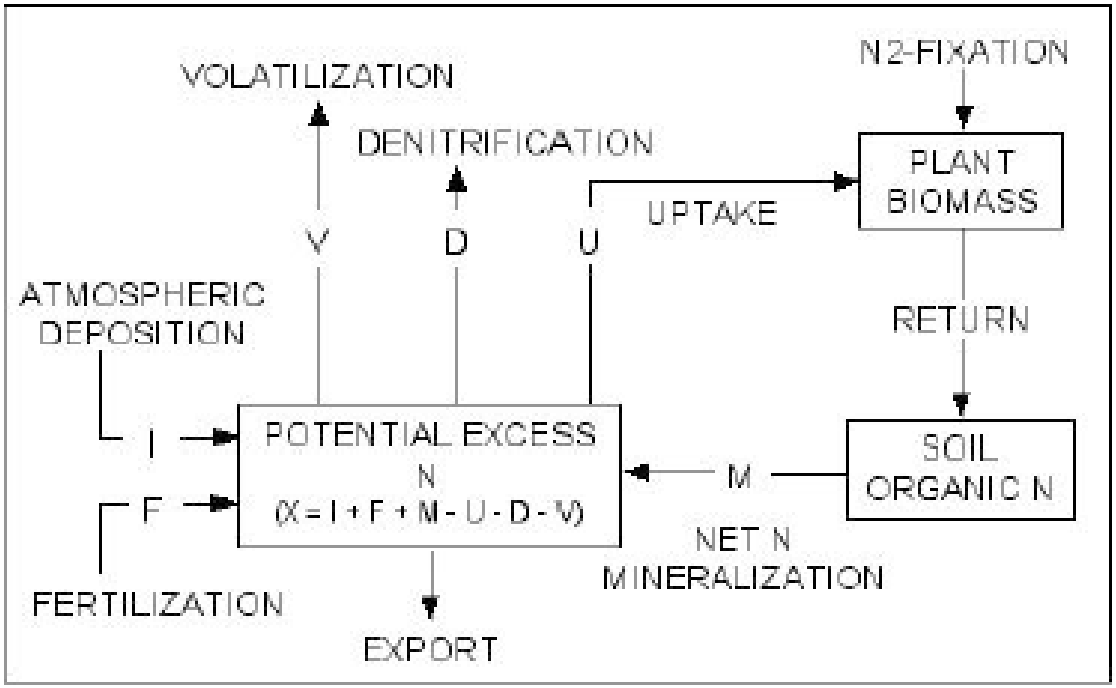
by

C. T. Garten Jr., R.A. Washington-Allen, and

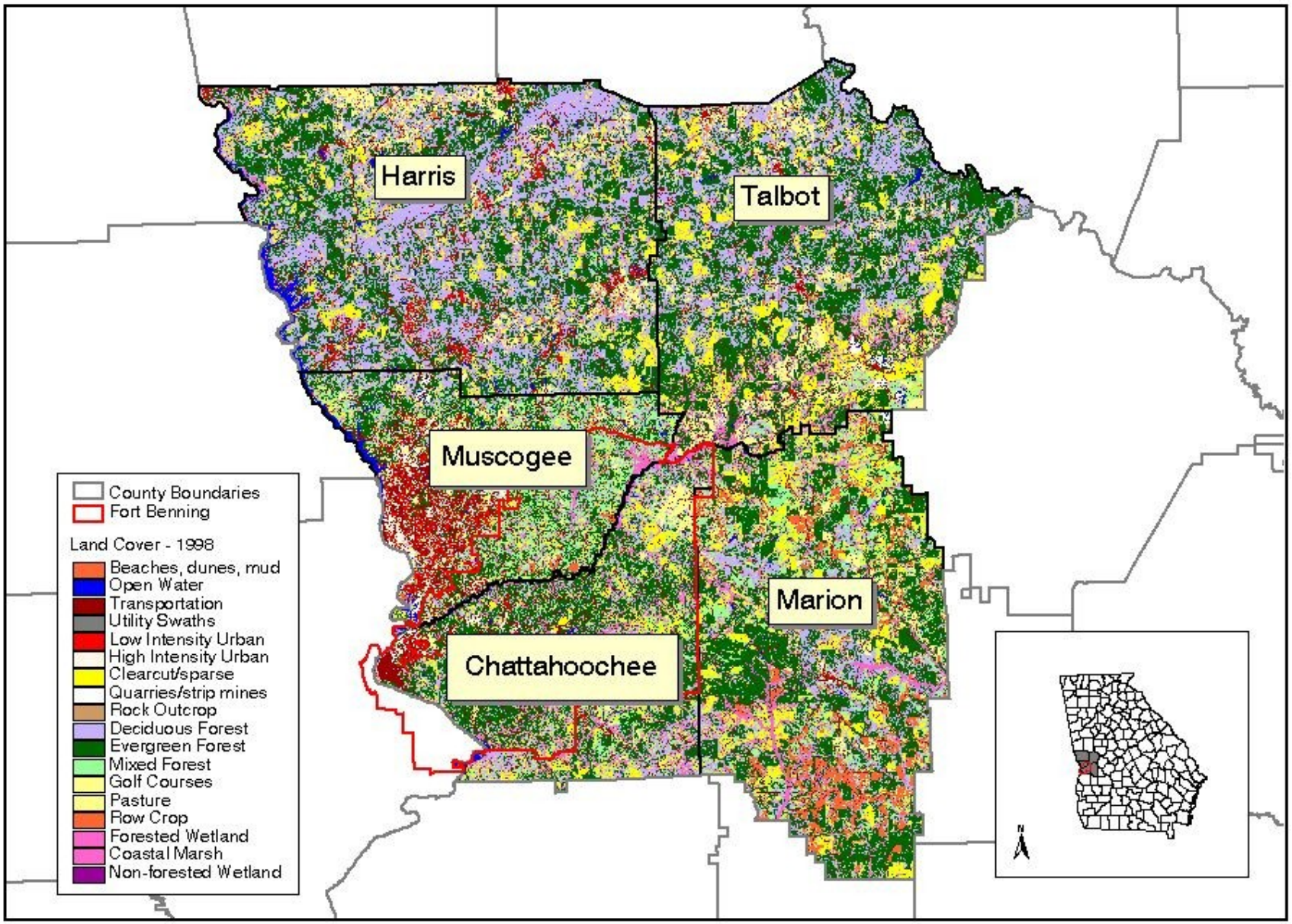




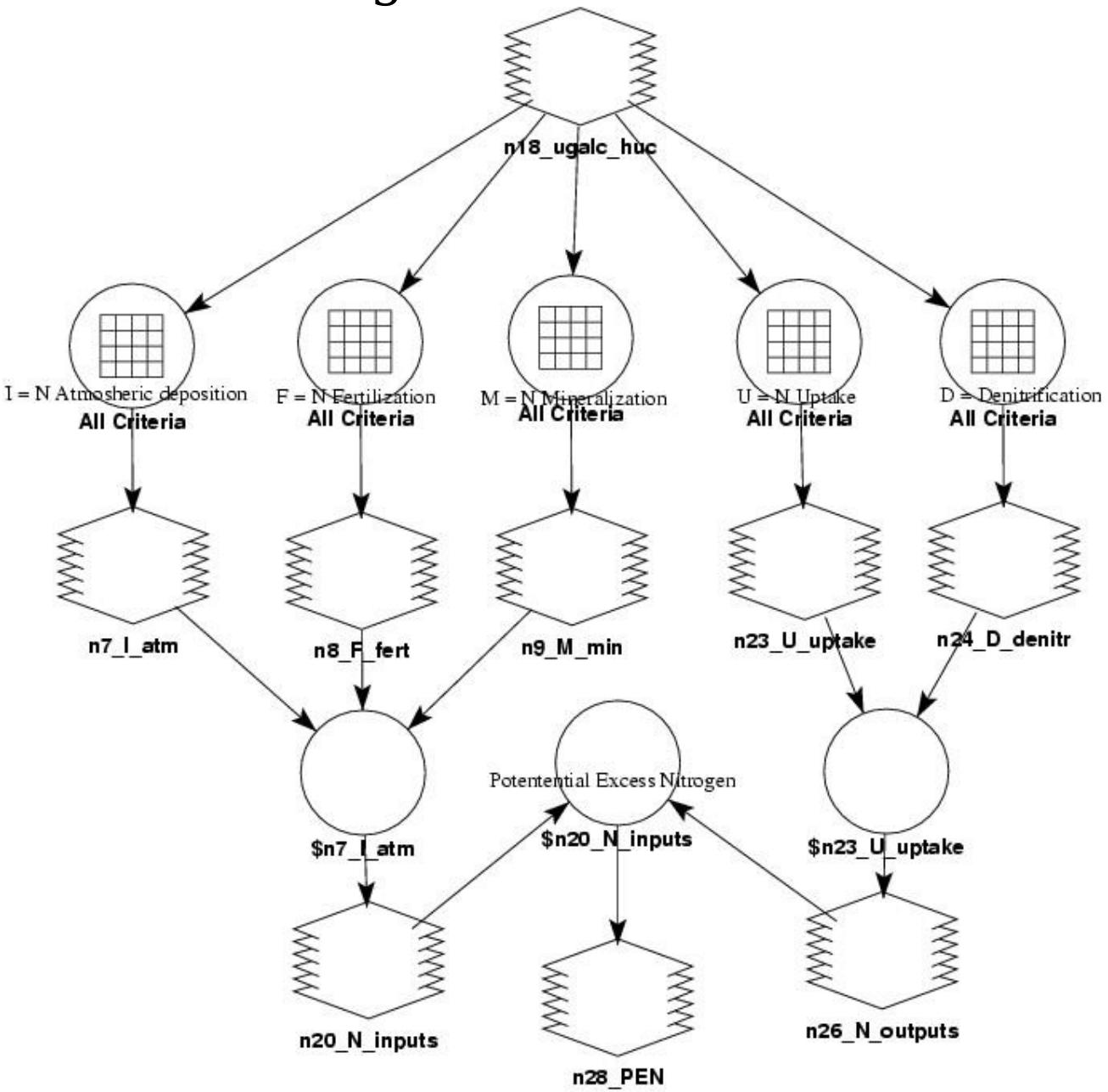
Nitrogen Flux Model



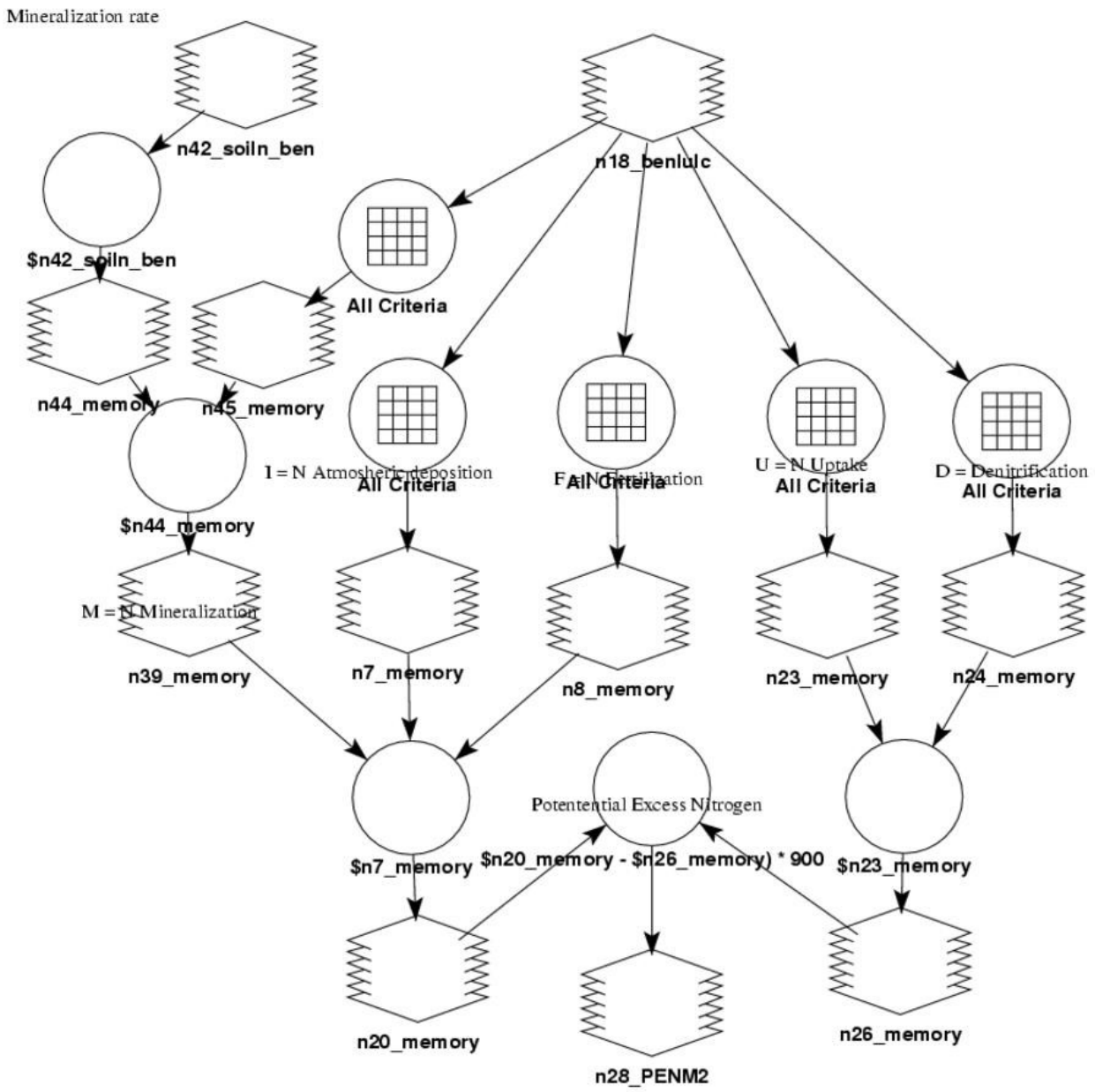
1997/1998 Land Cover Map from University of Geor



Nitrogen Mass Balance Model 1



Nitrogen Mass Balance Model 2



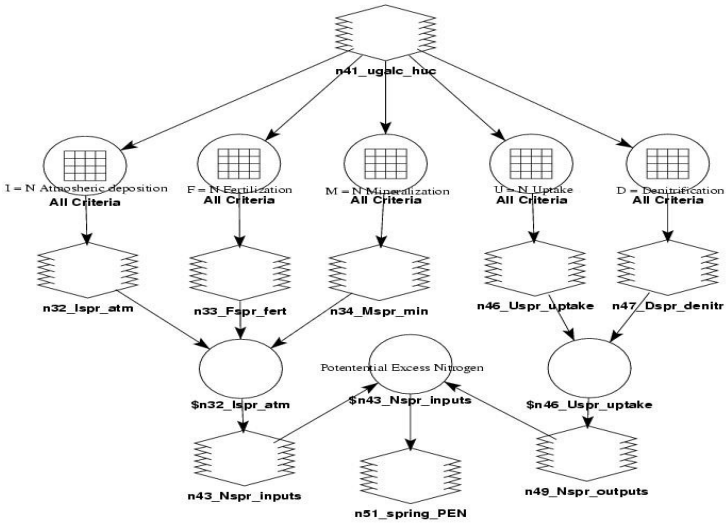
Potential Excess Nitrogen for Model 1 and Model 2 for F

Source

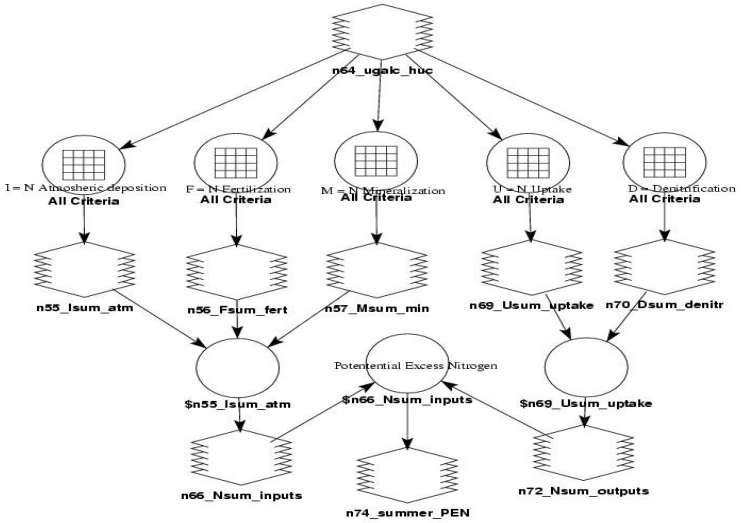
Sink

Seasonal Nitrogen Balance Model 1 for 5 Counties G

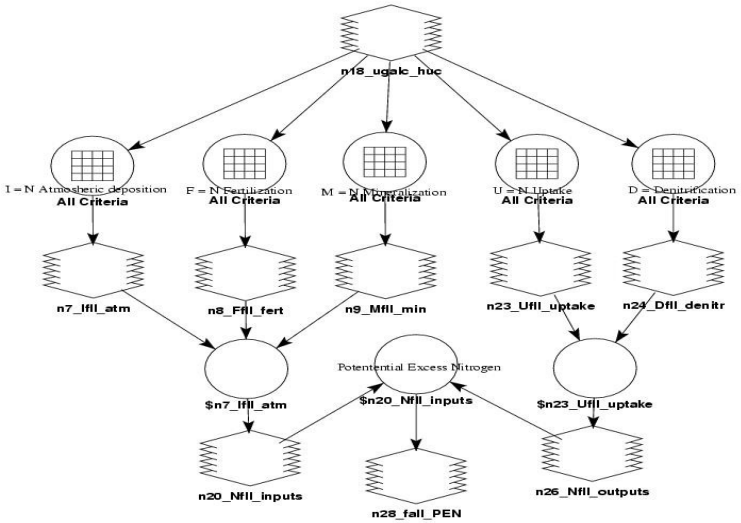
SPRING



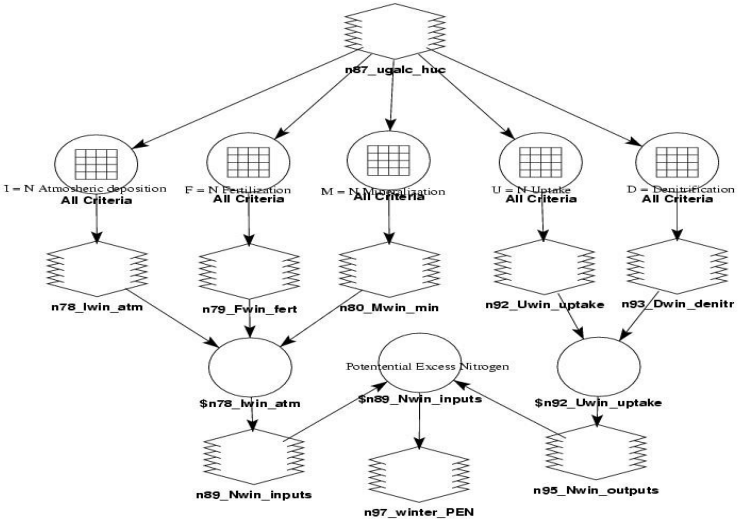
SUMMER



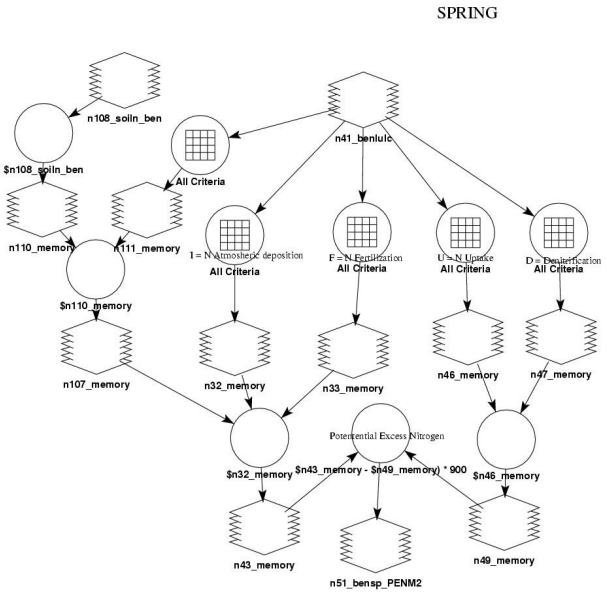
FALL

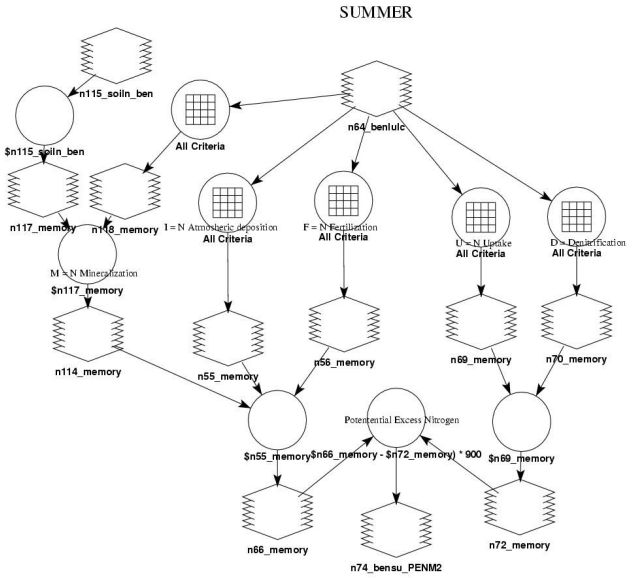


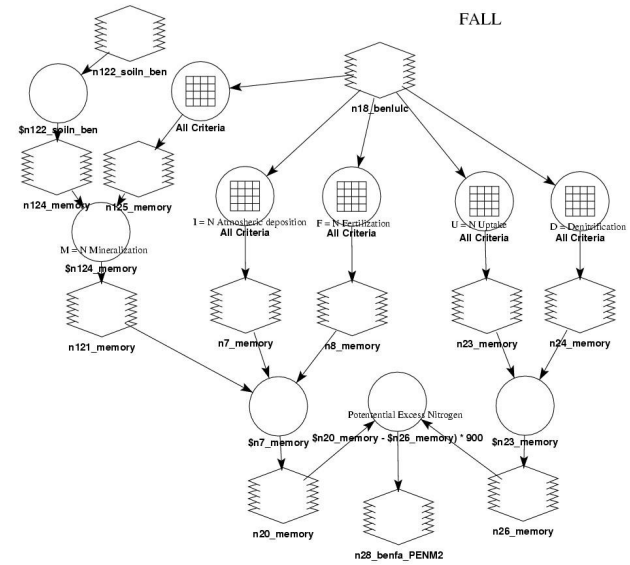
WINTER

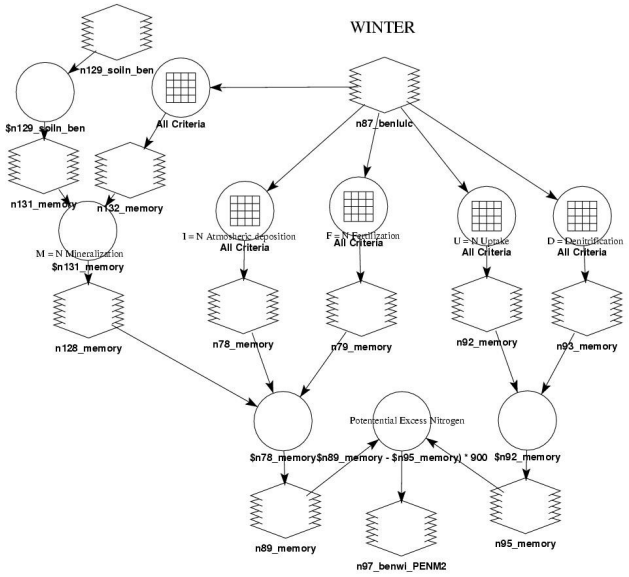


Seasonal Nitrogen Balance Model 2



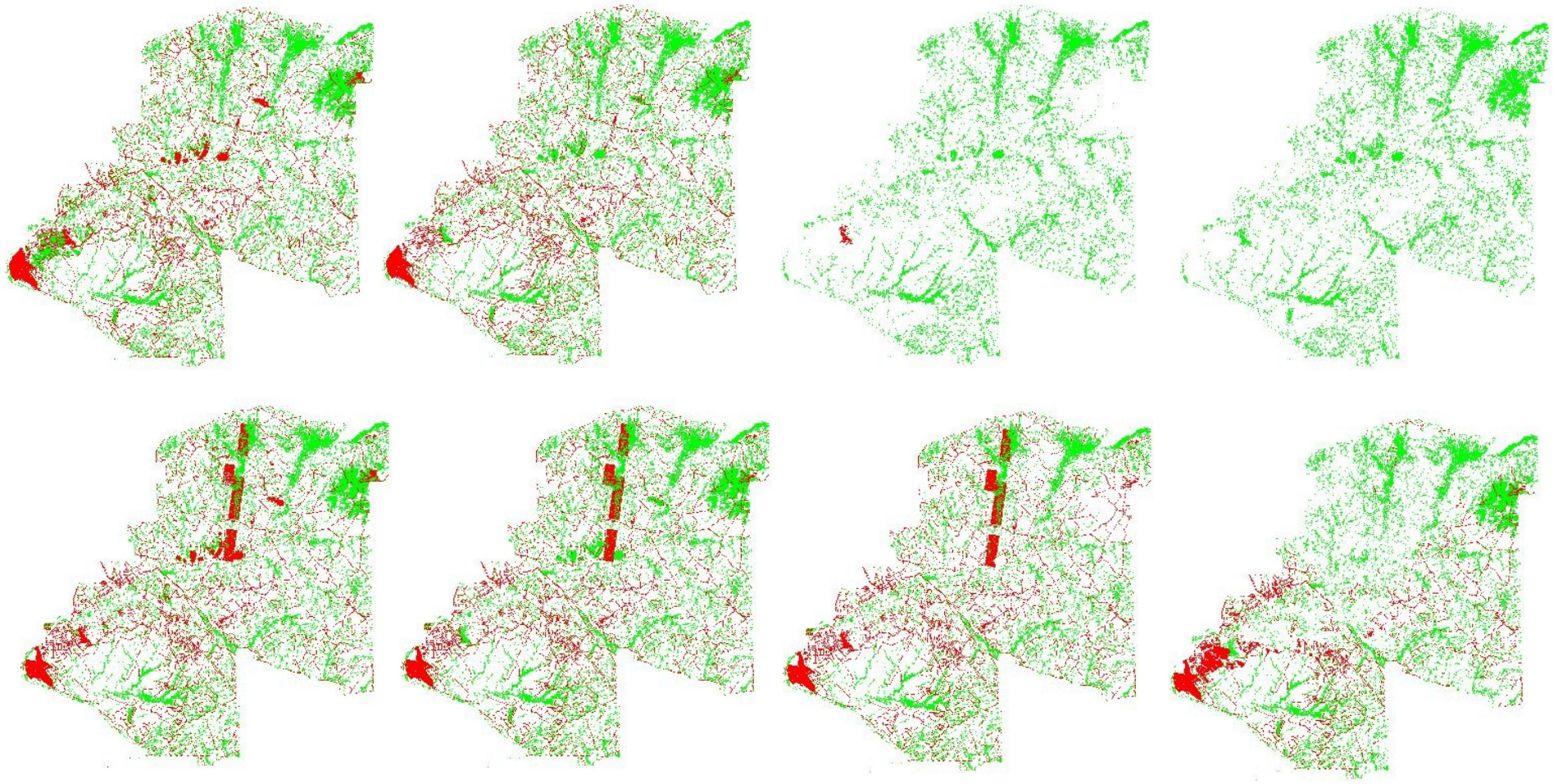






Seasonal Potential Excess Nitrogen Model 1 and 2

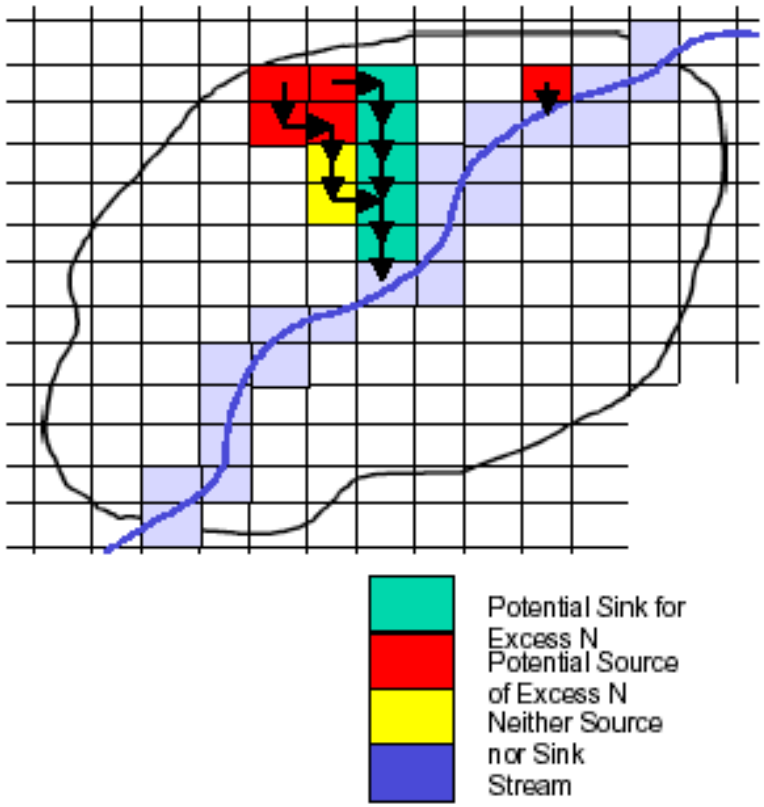
Spring Summer Fall Winter



Source Sink

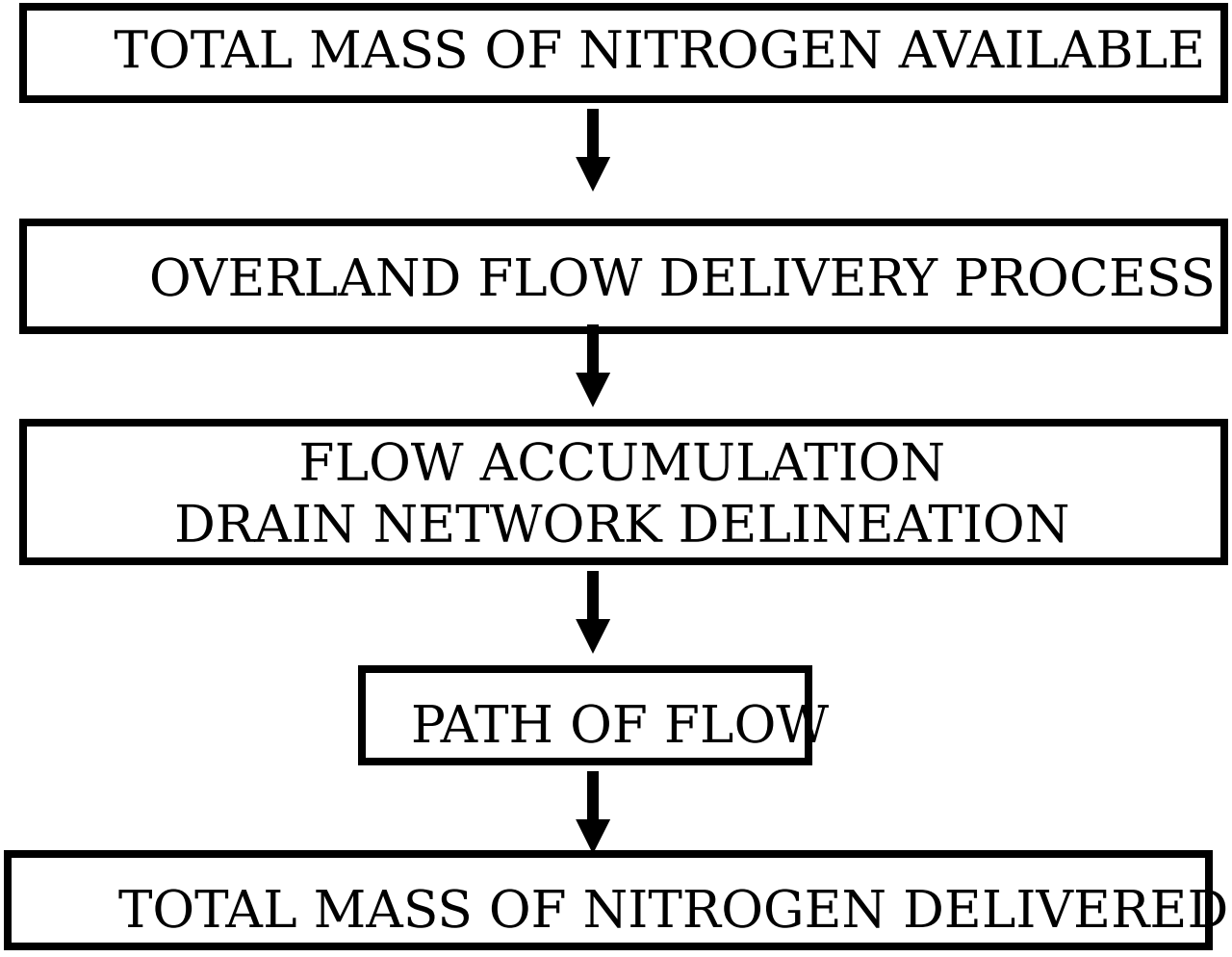
Conclusions

Nutrient Loading Water Quality Model: Howmuch PEN is exported from the Watersheds of Ft. Benning and its context?



MODELLING NITROGEN TRANSPORT

(Levine et al. 1993, Emani 1998)



MODELLING NITROGEN TRANSPORT

ASSUMPTIONS

- OVERLAND FLOW ONLY
- NO SUBSURFACE FLOW (OR IMPLICIT in input and output)
- DELIVERY RATIO (fractional transport): Surface conditions strain
- The Further a cell is away from stream the smaller its contribution

DATA REQUIREMENTS

1. ELEVATION (DEM):
    SLOPE ANGLE : defines direction and speed of flow of water and pollutants
    DIRECTION OF FLOW by comparing elevation of cell with elevation of neighbors
    LENGTH OF FLOW: the distance that water and pollutants are transported through a cell.
2. SOILS/Soil Survey:
    Mean Particle Diameter
3. LAND COVER
    MANNING'S ROUGHNESS COEFFICIENT
4. Potential Excess Soil Inorganic Nitrogen (PEN)

1. **Mass balance** calculation of available inorganic nitrogen: Input N - Output N = Potential Excess N/year (PEN)

(I + F + M) - (U + D + V)= PEN

2. **Trapping efficiency** calculation for Nitrogen (Levine et al. 1993):

$$TN_{trapped} = \frac{1}{1+e^{(-1.014+0.016d+26.83\theta-4.58\ln(n)+2.87\ln(mpd)+1.47dn-1.63d\theta)}}$$

where

TN = trapping efficiency for total nitrogen

d = distance of flow (meters)

mpd = soil mean particle diameter (mm)

n = Manning's roughness coefficient (Engman 1986)

θ = theta, slope angle (radians)

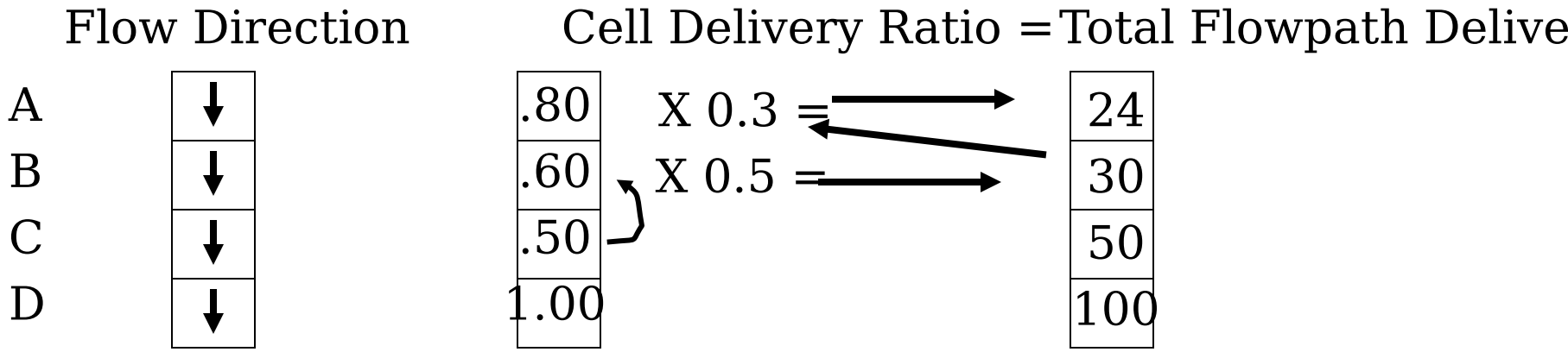
ln = natural log

3. Delineate Stream Network or Calculate Flow Accumulation from DEM and threshold to indicate drainage streams < 15 = 0 and >= 15 = 100.

a) overlay flow accumulation to delivery ratio where values >= 100 = 100 produces CELL DELIVERY RATIO:

4. Calculate Flow Direction.

a) based on flow direction calculate flowpath delivery ratio from cell delivery ratio.



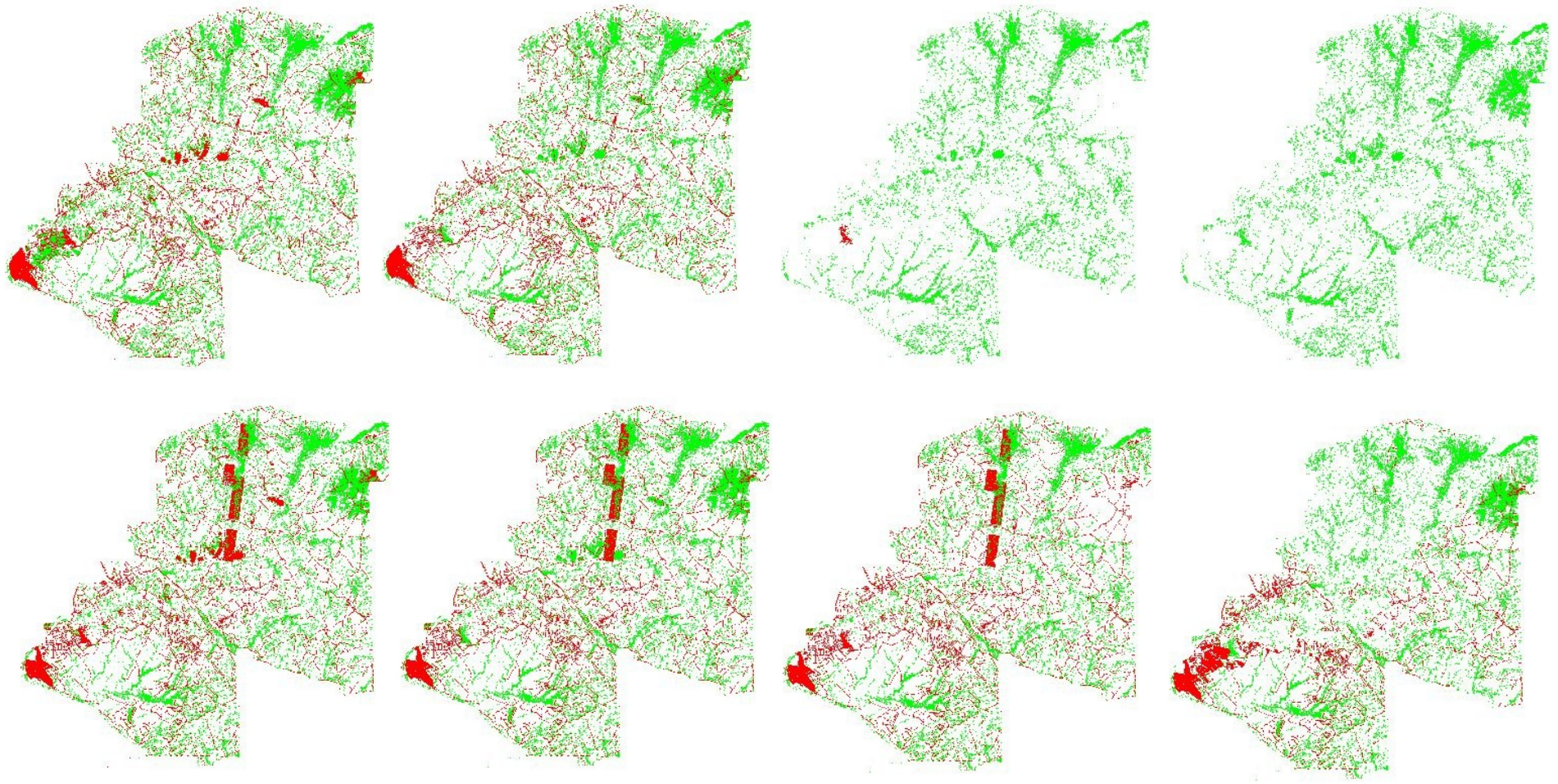
Potential Excess Nitrogen for Model 1 and Model 2 for F

Source

Sink

Seasonal Potential Excess Nitrogen Model 1 and 2

Spring Summer Fall Winter



Source Sink

5. Calculate Total Seasonal and Annual N Loading

Annual PEN M1 x Total Flowpath Delivery Ratio = N Loading M1

Annual PEN M2 x Total Flowpath Delivery Ratio = N Loading M2

Seasonal PEN M1 x Total Flowpath Delivery Ratio = N Loadin

Fall Winter Spring Summer

Seasonal PEN M2 x Total Flowpath Delivery Ratio = N Loadin

Fall Winter Spring Summer

Conclusions

References Cited

Emani, S. 1998. Nonpoint source pollution modeling, pp. 5-1 - 5-42. In: S. Emani (ed.), Applications in hazard assessment and management. United Nations Institute for Training and Research. Explorations in Geographic Information Systems Technology. Vol 6. The Clark labs for Cartographic Technology and Geographic Analysis, Clark University, Worcester, MA 01610, USA.

Engman, E.T. 1986. Roughness coefficients for routing surface runoff. Journal of Irrigation and Drainage Engineering 112:39-53.

Levine, D.A., C.T. Hunsaker, S.P. Timmins, and J.J. Beauchamp. 1993. A geographic information system approach to modeling nutrient and sediment transport. Oak Ridge National Laboratory, Environmental Sciences Division, Publication No. 3993. Oak Ridge, TN: Oak Ridge National Laboratory.